I N T E R I M R E P O R T

ON THE SURVEY FOR DAR ES SALAAM - LINDI

COASTAL LINK ROAD PROJECT

IN TANZANIA

NOVEMBER 12, 1970

OVERSEAS TECHNICAL CO-OPERATION AGENCY

GOVERNMENT OF JAPAN

C O N T E N T

1. INTRODUCTION:

Due to the fact that Rufiji River and other streams have been flooded over roads along the coast, the trunk route from which more than 10 percent of the total population are receiving benefits becomes untraffickable in about half a year.

In order to solve that serious problem, in response to the request of the government of Tanzania, Japanese Government sent a technical survey team headed by Mr. Kurita and studied the road project from Dar es Salaam to Mtwara from October to November 1970.

A plan constructing a new road located in the plateau where the influence of rivers is minimized had been proposed. However, the survey of this time was carried out for the purpose of planning a road along the existing coast roads. Although the road in the coast has disadvantage receiving serious influence of rivers, the sections of it requiring new construction or reform can be shortened since the proposed coast road is to improve existing roads. The coast road has also advantage giving great deal of benefits to the habitants along it.

In accordance with our survey, it was noticed that we have to solve two major problems with respect to the highway project along the coast.

The first is how to cross Rufiji River. Rufiji River not only floods in rainy reason but moves its river bed unsteadily every rainy season. Then in this report it is suggested to enable to cross Rufiji River by erecting a bridge over the section within which the flow channel may cause random movement, and by building embankment higher than flood level. Some additional bridges over flood control channels across the embankment are required. The place at which the proposed road crosses Rufiji River should be decided after studying technical advantage and construction cost. In this report our brief comments in this respect was described but detailed discussion is expected in our final report.

The second problem is the planning of bridges crossing minor rivers in the south of Rufiji River and the planning of highway considering stabilization of road surface. It is shown possible to solve those problems and our technical suggestions concerning with them are presented in this report.

As regards to the economic feasibility of this project it is anticipated that the development of the district along the proposed road will be accelerated by ensured transportation. Furthermore, it should be highly appreciated that more than 10 percent of population will be secured by permanent and all weather way of transportation. From this point of view, the procedure to maintain high benefit ratio to the amount

of investment by making a good use of existing roads and by removing obstacles of transportation step by step should be thoroughly studied. Analysing economic informations collected during our survey, our opinions in this respect will be materialized and presented in our final report.

2. OUTLINE OF FIELD SURVEY

2 - 1 Organization of Survey Party and Schedule.

The survey team was divided into two groups of A and B, mainly because of camping facilities.

A Group with two Land Rovers.

Route Survey	(Road Planning	Mr. Kurita	Member of the Mission
	(Bridge Planning	Mr. Sumitomo	
		Mr. Nishino	
Soils and Geology		Mr. Sugita	
Staying Japanese Executive Engineer		Mr. Sugiura	
Liaison Officer from the Comworks		Mr. Gulamali	
Labour		2 - 3 Persons.	

B Group with three Land Rovers and one truck.

Topographic Survey	(Mr. Nagashima (Mr. Tokumaru (Mr. Asahi	Member of the Mission
Soils and Geology	Mr. Mori	
Flood Marks Survey	Mr. Terashi	
Staying Japanese Executive Engineer	Mr. Sumiyoshi	
Liaison Officer from the Comworks	Mr. Joshi	
Technician from the Material Laboratory	(Mr. Msangi (Mr. Harahara (Mr. Mosha	
Labour	5 - 7 Persons.	

The survey work has been carried out in two phases; first, the overall site reconnaissance from October 15th to October 17th, and second, the detailed field survey from October 22nd to November 7th. The schedule of the latter is as shown in the following table:

BASE CAMP	A GROUP	B GROUP
Kilwa Masoko	OCT.22ND - OCT.30TH	NOV. 1ST - NOV. 7TH
Kibiti	OCT.31ST - NOV. 7TH	OCT.22ND - OCT. 31ST

2 - 2 OUTLINE OF INDIVIDUAL FIELD SURVEYS

2 - 2 - 1. Route Survey.

The Route survey necessary for establishing the plans for road improvement, bridge improvement, and new bridge construction has been executed mainly along Route 1 (Kibiti - Rusende - Utete - Nyam Wage) and Route 2 (Kibiti - Ikwiriri - Ndundu - Nyam Wage - Mohoro - Kilwa - Lindi). Rough topographic survey by means of hand levels has also been added in some section where vertical alignment is extremely poor or vehicular traffic seems to become impassable during rainy seasons.

Only rough site reconnaissance was made for Route 3 (Utete - Njinjo - Mbate - Mtandawala - Makangaga).

2 - 2 - 2. Soils and geology

(1) Foundation exploration for Rufiji River crossing

Two bore holes have been drilled on the left side levee of Rufiji River near Ndundu and Utete where ferry boat service is in operation. Sampling and measurement of bearing capacity of foundation ground in terms of the standard penetration value (N - Value) were carried out. Samples taken from bore holes will be subject to related testing under the care of the Material Laboratory of the Comworks.

(2) Soil Survey along the routes

Representative soil samples (72 in total) have been taken in 5 to 10 km intervals along Route 1 and Route 2, and sent to the material Laboratory for consistency test. Moisture - density relation test and CBR test will also be run for 14 typical samples among them. Representative samples of laterite and black cotton soils were shipped to Japan for complementary tests. Only 6 samples for consistency test have been taken on Route 3.

2 - 2 - 3. Topographic Survey

Longitudinal topographic survey was conducted near main rivers of Rufiji, Matandu, Mavudyi, Mbwemkuru, etc. Some Lateral topographic survey was also added in the control points. Maximum high water levels were recorded in the profiles, in joint work with 2-2-4. Flood marks survey, in order to prepare the basic informations necessary for bridge and road embarkment plan.

2 - 2 - 4. Flood marks Survey

Flood marks survey was made chiefly in the basin of Rufiji River. The scale and scope of flood in the past has been made clear and the

information for main bridge plan, plans for relief opening of flood water and slope protection of road embankment have been prepared. Oral interview to the local inhabitants was also utilized in this survey.

2 - 3 Collection of Existing Data and Informations
With the co-operation of Officers in the Comworks, the following data and informations have been collected. They are indispensable in preparing the final report.

(1) Hydrology

(2) Soils and Geology

(3) Economic Survey (Traffic survey included)

(4) Design standards and the standard specifications

(5) Informations for cost estimate (Maintenance cost included)

(6) A set of reports concerning the Dar es Salaam - Mtwara Link

3. DISCUSSIONS ON CROSSING RUFIJI RIVER

3-1 Hydrological and geological conditions.

The large amount of annual maximum discharge of Rufiji River, since measurement at stiegler's gorge started, was 7100 cu.m./sec in April 1956, 6600 cu.m./sec in January 1962 and 5800 cu.m./sec etc. being recorded. The flood flow over 5000 cu.m./sec appeared in 6 years within past 15 years. As the results of our survey it was identified that the flood in 1968 caused the highest water level in the section from Utete to Ndundu

As the crossing point of Rufiji River, Utete of the first route and Ndundu of the second route were taken into consideration. The first route is to cross between Rusende Village on the left bank of Rufiji River and Utete elevated by 100 to 150 feet. The main stream in the vicinity of this crossing point, seems to have relatively serious variation. In 1912 Rufiji River was supposed to flow along two channels; present flow channel and the other channel near Rusende Village. In comparing present channel to the one in 1952, it is noticed that the river was shifted by about half a mile. It is very hard to fix the water channel at such a crossing point and it requires enormous amount of cost for the improvement of river. According to shallow boring by a hand auger the soil near the ground surface at this crossing point is generally sandy though some portions are covered by black cotton clay of about 50 c.m. thick. Therefore no extreme difficulty in making foundations or embankment is expected. However, considering scouring effect when the river changes its flow channel, bridges of long span having deep foundations will be required. In the low land eroded by old current near Rusende some cohesive soils came out of auger boring. Detailed soil exploration by deep boring and testing of soil is required in order to avoid detrimental settlement of foundations and embankment.

It is recommended to use sandy soils in the north of Rusende to Kibiti. Lateritic sand distributed at 2 km north from Rusende towards Kibiti is considered suitable material as sub-grade of pavement.

The second route is to cross Rufiji River at Ndundu. During flood in 1968 this area, from the end of Ikwiriri Village through Rufiji River about 12 to 13 km was inundated, but no track of river movement since long time ago was observed. However, just upstream of the crossing point being considerablly curved, it happened in 1963 that overflow beyond the curved corner washed off the road on embankment just completed in 1962. Therefore improvement of the river at its meandering portion is required but generally the bridge over the river of which flow is relatively stable may be done with shorter one as compared to the crossing at Utete.

The subground in the flood plain around the Ndundu crossing consists of brown silty sand though it is overlayed with black cotton clay of about 50 to 60 cm thick. According to the boring at the left bank of Rufiji River, blue coloured dense clayey sand was encountered at the depth of 8 m. and also blue hard pan at 12 m. deep. So the foundation of bridges at Ndundu crossing well have no extreme difficulty if it is penetrated into the soil having enough bearing capacity and erosion resistance. The embankment on the flood plain will also be stable if it is properly designed considering the effect of seepage through it. The sandy soil in the flood plain may be used as embankment material provided surface black cotton is completely scraped off. The tops of embankment should be covered with lateritic sand to provide subgrade for pavement. In general remarkable consolidation settlement is not likely to happen, but thorough soil investigation of subground soil by deep boring and testing soil is recommended in order to secure the stability of foundations and embankment.

3 - 2 Highway Planning.

a) The first route(via Utete)

The distance of the first route is 45 km. from Kibiti to Utete and 33 km from Utete to Nyamwage, then 78 km. in total. The existing road from Kibiti to Utete having the width more than 6 m. maintains its road surface in good conditions providing lateritic sand being used as surface course. There are three portions in the distance of 5 to 15 km. from Kibiti where longitudinal gradient is 10 to 11%. In general sight distance of existing roads being not enough, the alignment of road has to be improved. The drainage in this section is generally good as the roads run in high land, but deep unprotected side ditch in the portion having large langitudinal gradient should be well

protected when the road is improved. Four wooden bridges are erected at present crossing Ruhoi River, but all of them are submerged in flood and approach road to the bridge at Utete side is lower than the bridge. Both sides of bridges therefore have to be improved.

The ground surface of the low land in the south of Ruhoi River being covered by black cotton clay, embankment higher than 1 m. is required between Ruhoi and Rusende.

In the flood area along Rufiji River the road has to be built on embankment having elevation of the point 4 km. from Rusende which has not been inundated during flood. Necessary protection of embankment and bridges over relief openings are recommended, since the road will take its role as a transversal levee of Rufiji River.

There is no inundated area due to the flood of Rufiji River throughout the section from Utete to Nyamwage. The river at 3 km. distant from Utete has been flooded remarkably. The other minor rivers reduce their flood flow in one or two hours. The subsoil there is generally brown fine sand or silty sand sometimes covered with thin layer of black cotton clay. Corrugated pipes are installed to drain flood flowing to Rufiji River, but they are not effective as the formation of the road is lower than the ground surface environ. The road on embankment and sufficient transversal drain conduits are recommended.

The road crossing the above mentioned relief openings having steep gradient as 10% or more must be made gentle slope, and simultaneously the height of bridges and their span have to be enlarged.

b) The second Route (via Ndundu).

The distance of the second route related with Rufiji River is 49 km. from Kibiti to Nyamwage.

The existing road in this section has good alignment in plan and elevation. The maximum gradient is 8% having enough width and road surface of good conditions.

The soil in the hilly area consists of lateritic sand or brown fine sand. The brown sandy soil is deposited in low land covered with their layer of black cotton clay. Black cotton clay in the flood plain is considered secondary deposites of black cotton washed out of original residual soil. Ordinarily the thickness of the secondary deposites of black cotton is in the order of 50 cm.

Necessary improvement for the section from Kibiti to Ikwiriri is drainage system and the embankment in the vicinity of Ruhoi River within 10 to 25 km. from Kibiti

The inundated area of Rufiji River starts from Ikwiriri Village. There is a road on embankment completed in 1961 and failed in 1962. The high water level in the past of 17 m. in elevation being indicated the existing levee should be made higher and more stable. The washed out portions of embankment, being weakened by stream erosion, should be opened for flood control. More bridges for the purpose of flood control shall be needed depending on the results of hydraulic computation.

The road embankment in the right bank of Rufiji River is also completed. As the trace of inundation is observed within 3 km. from the river bed, the embankment of this section has to be made higher and more stable.

The section from this point to Nyamwage has been completely improved in the distance of 19 km.

Consequently the second route being shorter than the first route by 39 km. or thereabout and containing considerable distance of, improved sections, from the view point of making short connection from Mtwara to Dar es Salaam via Lindi, the second route has considerable advantage in construction cost.

3 - 3 BRIDGE PLANNING

3 - 3 - 1 Main Bridge.

(1) Ndundu Route (Route 2)

In the actual survey, it was found that Rufiji River has the width of about 240 m. However, considering the planned flood discharge, and the bending and irregularities of upstream especially on the left side levee, the main bridge will be followed with an additional extention of about 350 to 400 m. in length with individual standard span of 40 m. on Ikwiriri side.

It is desirable to adopt 3-span truss superstructure of two lanes erected upon the well foundation, taking into consideration the construction cost, construction period, transportation of bridge members, and the result of boring.

(2) Utete Route (Route 1)

The length of main bridge here will be at least 2000 m., as the river bed of main stream and the stream center have shown frequent variations and instable conditions at Utete. Considerable difficulties are also anticipated in technical solution.

As far as the bridge planning is concerned, Utete route is less advantageous than Ndundu Route, because the total bridge cost of the former including the short bridges for relief openings of flood is assumed to be 3 or 4 times as much as that of the latter.

3 - 3 - 2 Relief openings for flood and short bridges.

(1) Relief Openings for flood water.

According to the survey results, flooded length of approach road in Ndundu route is supposed about 6 km. on the left side (Ikwiriri side) and about 3 km. on the right side (Ndundu side).

The total length of bridges for relief opening of flood water across the embankment will be finally determined after the detailed study of flood discharge has been completed. However, at least about 4 km. length which is equivalent to the sum of washed and damaged embankment sections seems necessary in total.

In order to minimize the initial construction cost and maintenance or repairing cost, use of standard beams with 20 m. span for superstructure and pile foundations with lateral beams by which pile heads are tied and braced, and upon which the standard main beams are supported is recommendable.

(2) Short bridge to cross small rivers.

Timber bridge is under construction in Ruhoi River at 17.5 k.m. south of Kibiti along Ndundu Route. According to the survey result, the bridge length of 100 m. will be necessary to overcome the flood in rainy seasons. Standard design mentioned in paragraph (1) above will also be applicable in this case.

In Utete Route north of Rufiji, there are found 3 sections where bridges of about 270 m. 370 m. and 470 m. should be constructed at 17.2 km., 28.7 km. and 35.5 km. southwest of Kibiti, respectively. The problem of these bridges will be easily solved by the use of the same standard design.

4. PLANNING OF HIGHWAY AND BRIDGES TO THE SOUTH OF RUFIJI RIVER.

To the south of Rufiji River the first route (Nyamwage-Mohoro-Lindi) of 270 Km and the third route (Utete-Njinjo-Mandwa-Lindi) of 380 km have been surveyed.

4-1 The first route

The section of 76 Km from Nyamwage via Mohoro to Miteja is located in alluvial plain. The subsoil consists of brown silty sand or fine sand but recent flood deposits in relatively lower land is covered by black cotton clay or dark brown

organic clay. The elevation of the existing road surface is lower by 20 to 30 cm as compared to the ground level. The vicinity of Mohoro was under the flood water of about 1m. deep in 1968.

The section of 29 km. from Miteja to Nangurukuru is located on the hill of good soil having elevation of 30 to 50 m. containing gravel. But there are many portions in which, taking too much care of drainage, alignment in both plan and profile is poor. The hill is cut off by small rivers into valleys of 10 to 15 m. in elevation. The valley especially flooded and closed for traffic is Matandu River.

In the section of 56 km. from Nangurukuru to Mitolo, there are many minor rivers such as rivers in Ukuli area, Mavuji River and so on. The longitudinal gradient of the existing road in those river crossing is very poor. Because of poor drainage system, some sections of the road may become stream channel during heavy rain. While in the plain rain water tends to overflow across the road.

In the section of 75 km. from Mitolo-Mchinga, about 20 km. close to Mitolo is the route making efficient use of hill crest has good alignment in plan and elevation. But the route to the south of Nondwa has similar conditions as the one between Nangurukuru and Mitolo.

From Mchinga to Lindi (about 33 km.) the road running on a hill of lateritic sand is good in alignment and road surface. But the portion going up to the hill from Mchanga has poor alignment in plan and elevation and also eroded by rivers.

4 - 2 The third route

The Route of 130 km. from Utete to Njinjo is located along the existing road having width of 3.5 m. or thereabout, poor road surface. Especially from Utete to Tawi the road has been scoured by stream running on the road itself. The road is also the path of Elephants and other wild animals. This route is taking a roundabout way to the west in order to avoid Mt. Nangangnti so its distance is considerably long. The number of rivers are less as the route runs along the slope of mountains, but a river near Kwambe flowing to Utete and Matandu River are pressured to have large stream velocity and depth of water after rain. The road near Kwamba runs parallel to a river and the road itself is likely to be washed away. Thereafter the route passes on flat topography.

The road from Njinjo to Mbate is quite well improved, but, between Mbate and Mandwa, road is narrow and it is closed at Mavuji Bridge fallen down. In this route large number of structures are required as numerous individual streams or branches of rivers may cause deep and quick current of flood flow.

4 - 3 Discussion on the route location and planning of the first route.

1. Sufficient alignment in plan and elevation will be obtained by improving existing roads locally. In detail planning hereafter should be performed on the map of 1/2500 scale produced by aerial photo-survey. Design should be made considering drainage direction and treatment of drained water.

   However, as regards to the route, around Mohoro, the road is to be on the embankment higher than 1.5 m, or change of route has to be studied in order to avoid inundation.

2. As regards to soil conditions, discussion will be made after obtaining results of testing which is being conducted in the material laboratory of Comworks. At present after reconnaisance along the route, the following comments are considered worthwhile to note:

   a) The hill consisting of lateritic sand or terrace deposits such as sandy ground in the vicinity of Kilwa is considered good for subgrade or road materials.

   b) Some part of hill consisting of brown to yellow residual clay is not suitable as subgrade. The highly plastic soil in the hill should be removed and replaced with sandy materials obtainable from the nearest borrow-pit if it is found close to road surface.

   c) The alluvial deposits in low land mainly consists of brown silty sand, or fine sand. Those alluvial desposits may be used for embankment and probably adopted as subgrade if it is properly densified. However the black cotton clay covering recent flood deposits are not considered suitable as subgrade. It should be removed and replaced with granular materials if it is found close to road surface. The use of black cotton as embankment material will be studied by supplementary testing of it in Japan.

3. Poor alignment in plan is caused by making the road pass through the crest of hills and letting it go down to the river bed. Therefore the alignment should be improved by building bridges of enough length and shift the route to either upstream or downstream of the river. The span of minor bridges should be determined not only by the river flow but taking into consideration of vertical gradient of the road.

4. Transversal drainage is required for the portion where longitudinal gradient is high in order to drain quickly in lateral direction.

4 - 4 Bridge Planning

4-4-1 Major Bridges.

There are 3 major rivers of Matandu, Mavudyi and Mbwemkuru south of Rufiji River. The results of survey and the bridge planning across these rivers are as follows:

1. Matandu River.

According to the survey results, flood area extends over about 2 km. along the existing road between Matandu River and the river about 2.1 km. north of Matandu. The average flood level is about 70 cm. above the existing road surface.

Main bridge to cross over Matandu River should be about 80 m. of 1 span in order to minimize the influence of extremely rapid main stream which is anticipated to scour the river bed and to damage the both sides of the river. A considerable length of short bridges for relief opening of flood water will be necessary north of Matandu River, however, the exact figure will not be established until the detailed study is complete.

2. Mavudyi River.

Length of flood area around the river is about 500 m. In the center of main stream, the bridge of 50 m. span will be necessary. An appropriate number and length of relief openings will be required on both sides of the river.

3. Mbwenkuru River.

Flood area is measured as about 1100 m. in the survey. Main stream close to the left side has the maximum depth of 9 m. during flood season showing the rapid stream velocity. In order to avoid the influence of river bed scouring and abutment damage, the main bridge of about 80 m. span will be necessary. A considerable length of relief openings on both sides of this main bridge is desirable.

4-4-2 Other short bridges.

1. Utete-Nyamwage Route.

At about 2.6 km. southeast of Utete (KP. 47.8 km. from Kibiti), about 160 m. bridge will be necessary. However, the design and construction of this bridge will be comparatively easy as it is suggested that the effect of flood stream upon the bridge is small.

2. Others.

In addition to those bridges mentioned above, the total number of 55 and the total length of about 1300 m. of short bridges are considered necessary for the bridge planning along the route. They are of individual length between 10 to 60 m. and will be standardized without difficulties.

5. SUMMARY AND RECOMMENDATION.

In the technical survey of Dar es Salaam - Mtwara Road Project, two proposed routes to the Rufiji Crossing and two routes in the south of Rufiji River, one via Mohoro and the other via Njinjo have been subjected to our study. Combining those routes four different comparative routes have become objects to be studied.

The planning of bridge crossing Rufiji River and the related road and structures give the greatest influence to the whole project both financially and technically. After our survey we should like to say that it is technically possible to build a road crossing Rufiji River and flood plain in both sides of it. A bridge crossing over the area where main stream have passed or may pass in future will be built. The proposed road will pass the flood plain on the levee, equipped with sufficient relief openings to control the flood flow, over which short span bridges shall be erected.

Out of two comparative routes we consider it recommendable to select the route via Ndundu because of the following reasons:

1. Greater the change of main stream is, a bridge of longer span is required for the river having unstable, stream channel like Rufiji River. From this point of view, a longer bridge will be required at Utete side, where the variation of stream is greater than Ndundu side. It will result in higher cost and technical difficulty of Utete Crossing.

2. As far as the approach road planning towards the main bridge is concerned, Ndundu route is far better than Utete route, as the total length is considerably shorter and the flood area is limited near Rufiji basin while Utete route would require a considerable length of bridge construction and road improvement in several sections which are flooded by small branch rivers of Rufiji.

   Road-bridge planning to cross over Rufiji River, which will give a serious influence upon the construction cost of the Kibiti - Lindi Road, will require a huge amount of

cost if they are designed against the probable extraordinary flood of 10,000 to 15,000 cu.m./sec. Therefore, the flood control effect of the proposed Stiegler's Gorge Dam Project should be taken into account when designing the approach embankment and a series of short bridges to allow the relief openings of flood water across the embankment, although the main bridge should be designed based on the probable maximum flood.

In the route to the south of Rufiji River, number of bridges crossing medium to small rivers are required. The road approaching to those bridges has to be improved as existing roads are too steep in those places, Black Cotton Clay or highly plastic residual clay have to be removed and replaced with granular materials when those plastic soil is found in the elevation near the road surface. However, the design and construction of this route is considered technically feasible. No extreme difficulty is expected.

In comparison between the route via Mohoro and via Njinjo, we consider that Mohoro Route is recommendable because of the following reasons:

1. Njinjo Route has greater distance, passes through area of low population and its construction cost is not much cheaper than Mohoro Route.

2. The maintenance of existing Mohoro road would be still needed even if Njinjo Route was selected, which will impose additional burden.

This interim report presents the outline of our survey and brief comments on the planning of road and bridges. More detailed planning with the estimation of construction cost will be made in coming several months and involved in our final report. Economic feasibility such as benefit of this project will be also materialized.

However, because of insufficient topographic and geologic informations our report will be limited to what we can obtain by analysing data available at present. In order to make the project study more concrete and accurate, the further field survey as follows are considered inevitable.

a) Soil exploration at the site of major bridges and embankment above compressible soil.

b) Machine augering of soils and aggregates along the selected route, and testing of samples.

c) Topographic survey at the site of birdges and other structures.

d) Aerophotometric survey and mapping along the selected route.